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CHANGES IN COMPOSITION OF AMERICAN FERTILIZERS, 1880–1932

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INTRODUCTION

During recent years many changes have occurred in the composition of fertilizers. The plant-food content of most of the older fertilizer materials, such as superphosphate, has increased. Some materials of low total plant-food content formerly used in large quantities in mixed goods are no longer available for this purpose or the supply is limited and many new ones with high percentages of plant-food elements are now widely used in making mixtures. It has been necessary, therefore, to raise the average analysis of fertilizer mixtures very materially or to dilute them with sand or other filler.

It seemed desirable to determine the extent of the changes that have occurred in the composition of mixed fertilizers during the past half century in the country as a whole and in the various States. An attempt has been made to do this, and the results are given in this circular.

FERTILIZER MATERIALS

The kind and quality of the materials used in making mixed fertilizers change from time to time. In order to determine the average composition of the materials used in the years covered by this study, analyses were collected from the literature and averaged. The smallest number of determinations used to find the average composition for any material in a given year was 32, and the largest was 9,354. In every case the determinations were secured from a variety of sources, and the results are believed to be representative of actual conditions.

It was found that the content of plant food in most of the materials used in mixed fertilizers has increased in recent years. For example, the average percentage of available phosphoric acid in superphosphate in 1880 was 11.01, in 1910 it was 15.68, and in 1932 it was 18.31.

These changes in composition have been due to changes in the source of raw materials, to changes in methods of manufacture, and to the preparation of much drier products than formerly.

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COMPLETE MIXTURES

A number of sources of information are available from which the average composition of mixed fertilizers can be determined. For every second year starting with 1925 the United States Census Bureau has reported by States the average guaranteed analysis of fertilizers produced. A number of State fertilizer-control officials also report annually the tonnage by grade of the mixed fertilizers consumed in their States.

The average grade produced or consumed is not the same, however, as the composition found by averaging the results of chemical analyses, because the term "grade", as commonly used, means the minimum percentages of nitrogen, phosphoric acid, and potash below which the manufacturer guarantees that the composition of his product will not fall, and on an average the real percentages are higher than those of the guaranteed grade. It is of greater value to know the actual composition than the average grade. The difference between the guaranteed and actual composition is called the "overrun" and varies widely in different States and in different years. The average overrun must therefore be determined before the average composition can be calculated from tonnage figures based on grade.

The average overrun for each State and year was first determined by calculating the average difference between the guaranteed composition and that found by analysis as reported by the State control officials. A weighted average overrun for the United States for certain years was then calculated from the State figures, which were given a weight equal to the number of thousands of tons consumed in that State. For the years since 1910 the analyses represented over 90 percent of the fertilizer consumed.

The average total plant-food overrun was formerly much higher than at present, as will be noted in table 1. The overrun of available phosphoric acid has always been much greater than those of nitrogen and potash, but the quantity of phosphoric acid present has also always been much higher.

TABLE 1.—*Average overruns* [1] *of plant food supplied in complete mixed fertilizers in excess of that guaranteed in stated years*

State	1880				1890				1900			
	N	Available P_2O_5	K_2O	Total	N	Available P_2O_5	K_2O	Total	N	Available P_2O_5	K_2O	Total
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Maine	0.41	1.16	0.63	2.20	(2)	(2)	(2)	(2)	0.17	0.68	0.39	1.24
New Hampshire									.38	.63	.24	1.25
Vermont					0.36	0.90	0.44	1.70	.13	.78	.33	1.24
Massachusetts	.29	.64	.36	1.29	.22	1.17	.63	2.02	.39	.67	.54	1.60
Rhode Island					.11	.50	−.09	.52	.19	.74	.41	1.34
Connecticut	.71	.88	2.07	3.66	.32	1.41	.40	2.13	.33	1.45	.50	2.28
New York	.38	1.48	.33	2.19	.12	1.01	1.02	2.15	.10	1.28	.41	1.79
New Jersey	.13	.40	.18	.71	.20	−.07	.21	.34	.17	.67	.68	1.52
Pennsylvania									.16	.48	.28	.92
Maryland					.32	1.08	.10	1.50	.09	.76	.31	1.16
Virginia	.30	1.17	.32	1.79	.20	.57	.55	1.32		.57	.24	.81
North Carolina	.26	1.20	.39	1.85	.16	.80	.35	1.31	.24	.66	.30	1.20
South Carolina	.43	.71	.22	1.36	.31	1.15	.67	2.13	.17	1.31	.28	1.76
Georgia					.54	1.85	.62	3.01	.28	1.03	.38	1.69
Florida									.09	1.35	.59	2.03
Tennessee					.28	.12	.44	.84	.32	1.87	.27	2.46
West Virginia					.19	.45	.13	.77	.29	.89	.56	1.74
Ohio									.18	.28	.12	.58
Wisconsin										.83	.79	1.62
Weighted average	.33	.96	.38	1.67	.30	1.10	.53	1.93	.18	.94	.35	1.47

Footnotes at end of table.

TABLE 1.—*Average overruns of plant food supplied in complete mixed fertilizers in excess of that guaranteed in stated years*—Continued

State	1910				1920				1925			
	N	Available P_2O_5	K_2O	Total	N	Available P_2O_5	K_2O	Total	N	Available P_2O_5	K_2O	Total
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Maine	0.31	0.23	0.57	1.11	0.19	0.34	0.18	0.71	0.07	0.06	0.39	0.52
New Hampshire	.14	.95	.08	1.17	.04	.26	.09	.39	.09	.53	.15	.77
Vermont	.29	.80	.33	1.42	.35	.25	−.55	.05	.24	.67	.33	1.24
Massachusetts	.24	.64	.70	1.58	.23	.18	.10	.51	.20	.62	.33	1.15
Rhode Island	.22	.32	.57	1.11	.16	.11	.33	.60	.13	.27	.36	.76
Connecticut	.11	1.14	.45	1.70	.12	.44	.07	.63	.07	.41	.32	.80
New York	.08	.44	.34	.86	.07	.39	.06	.52	.07	.40	.08	.55
New Jersey	.06	−.01	.51	.56	.02	.13	.09	.24	−.03	.12	.17	.26
Pennsylvania	.09	.44	.36	.89	.12	.39	.19	.70	.14	.56	.40	1.10
Maryland	.04	.07	.37	.48	.04	.74	.12	.90	------	.31	.23	.54
Delaware	------	------	------	------	−.06	−.11	.31	.14	.11	.23	.41	.75
Virginia	−.01	.68	.17	.84	−.09	.48	−.17	.22	.01	.51	.10	.62
North Carolina	.26	.53	.05	.84	−.08	.21	.06	.19	−.01	.07	−.02	.04
South Carolina	.08	.85	.32	1.25	.18	.55	.20	.93	.07	.44	.10	.61
Georgia	.22	.67	.39	1.28	.03	.54	.10	.67	.02	.32	.23	.57
Florida	.18	.90	.55	1.63	.32	.47	.36	1.15	.03	.67	.34	1.04
Alabama	.31	.51	.22	1.04	.04	1.21	.20	1.45	−.07	1.11	.07	1.11
Mississippi	------	------	------	------	−.18	1.00	.04	.86	.03	.24	.08	.35
Tennessee	.01	1.08	.15	1.24	.02	.38	.02	.42	------	.69	.05	.74
West Virginia	.10	.70	.69	1.49	−.12	.48	.16	.52	.04	.59	.19	.82
Ohio	.44	.70	.34	1.48	.04	1.11	.16	1.31	.05	.68	.57	1.30
Indiana	.17	.90	.03	1.10	.17	.50	−.07	.60	.10	.30	.10	.50
Wisconsin	.21	1.17	.63	2.01	.39	.56	.15	.32	.05	.42	.36	.83
Missouri	------	------	------	------	------	------	------	------	------	.61	.10	.71
Arkansas	------	------	------	------	.08	1.00	.05	1.13	.10	.47	.01	.58
Louisiana	.13	1.09	.27	1.49	------	.68	.20	.88	.07	.69	.47	1.23
Texas	------	------	------	------	−.07	.76	−.07	.62	−.04	.91	.22	1.09
Oregon	.35	−.07	1.63	1.91	−.24	.13	−.51	−.62	−.05	.31	−.67	−.41
California	.15	.57	.27	.99	.15	.38	.13	.66	.15	1.22	.32	1.69
Puerto Rico	------	------	------	------	.04	.17	.01	.22	−.09	.40	.11	.42
Weighted average	.17	.64	.30	1.11	.05	.52	.11	.68	.03	.45	.16	.64

State	1930				1931				1932			
	N	Available P_2O_5	K_2O	Total	N	Available P_2O_5	K_2O	Total	N	Available P_2O_5	K_2O	Total
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Maine	0.12	0.23	0.28	0.63	0.06	0.16	0.38	0.60	0.17	0.37	0.27	0.81
New Hampshire	.06	.50	.09	.65	.04	.56	.03	.63	.12	.35	.09	.56
Vermont	.25	.77	.39	1.41	.15	.54	.23	.92	.20	.16	.28	.64
Massachusetts	.16	.42	.28	.86	.27	.34	.30	.91	.25	.38	.24	.87
Rhode Island	.01	.15	.29	.45	.07	.77	.28	1.12	.01	.80	.38	1.19
Connecticut	.15	.53	.38	1.06	.21	.49	.26	.96	.04	.62	−.03	.63
New York	.07	.45	.13	.65	.08	.76	.20	1.04	.15	.59	.18	.92
New Jersey	.03	.05	.17	.25	.08	.38	.27	.73	------	.39	.17	.56
Pennsylvania	.06	.44	.37	.87	.11	.70	.22	1.03	.09	.39	.25	.73
Maryland	.06	.48	.39	.93	.10	.43	.34	.87	.13	.66	.29	1.08
Delaware	.13	.24	.35	.72	.16	.26	.37	.79	.14	.28	.43	.85
Virginia	.03	.35	.10	.48	.07	.35	.09	.51	.05	.22	.06	.33
North Carolina	.05	.09	.10	.24	.09	.13	.10	.32	.05	.22	.17	.44
South Carolina	.08	.66	.24	.98	.07	.92	.20	1.19	.06	.89	.20	1.15
Georgia	.07	.57	.22	.86	.04	.56	.23	.83	−.01	.34	.25	.58
Florida	.50	.45	.37	1.32	.13	.55	.23	.91	.20	.59	.22	1.01
Alabama	.05	1.06	.16	1.27	.11	.71	.12	.94	.10	.85	.22	1.17
Mississippi	.06	.17	.13	.36	.07	.22	.12	.41	(2)	(2)	(2)	(2)
Tennessee	−.06	.39	.04	.37	.05	.37	.18	.60	−.01	.46	.20	.65
West Virginia	.10	.44	.24	.78	.09	.97	.10	1.16	.06	.74	−.01	.79
Ohio	.10	.93	.44	1.47	.13	.64	.58	1.35	.08	.75	.28	1.11
Indiana	.12	.72	.73	1.57	.17	.60	.30	1.07	.25	.80	.15	1.20
Minnesota	.04	.23	.41	.68	.13	.86	.46	1.45	.07	.22	.24	.53
Wisconsin	.09	.45	.16	.70	.19	.62	.49	1.30	.09	.64	.35	1.08
Missouri	.06	.32	.33	.71	.05	.54	.32	.91	.05	.96	.45	1.46
Arkansas	.18	.19	.17	.54	.19	.15	.19	.53	.15	.49	.15	.79
Louisiana	.09	.45	.21	.75	.13	.64	.32	1.09	.08	1.04	.22	1.34
Texas	.05	.04	.09	.18	.07	.24	.10	.41	.04	.30	.16	.50
Oklahoma	.04	.79	.60	1.43	.08	1.39	.02	1.49	(2)	(2)	(2)	(2)
Oregon	.02	.18	.65	.85	.04	.10	.63	.77	.25	−.07	.63	.81
California	.12	.93	.47	1.52	.15	.35	.32	.82	.32	1.19	.33	1.84
Puerto Rico	.08	.52	.21	.81	.08	.34	.25	.67	.28	.39	.29	.96
Weighted average	.09	.47	.23	.79	.09	.49	.21	.79	.10	.52	.21	.83

[1] A minus sign indicates average fertilizer contained less of this element than was guaranteed.
[2] No data available.

The average compositions of the complete mixed fertilizers produced in the United States in certain recent years, calculated by adding the appropriate overruns to the census (*5*)[1] figures previously mentioned, are given in table 2.

TABLE 2.—*The average composition of complete mixed fertilizers produced in stated years*

Year	Nitrogen	Available phosphoric acid	Potash	Total plant food
	Percent	*Percent*	*Percent*	*Percent*
1925	2.7	9.1	4.0	15.8
1927	2.7	9.0	4.4	16.1
1929	2.8	9.9	4.6	17.3
1931	3.3	9.1	4.8	17.2

The average composition of mixtures consumed during certain years at intervals from 1880 to the present were also computed by the following method: The average analysis grade consumed was determined for each State for which tonnage figures were available, and to this was added the appropriate overrun for that State and year. When tonnage figures by grade could not be obtained the results of all the analyses reported by the fertilizer-control laboratory for that year were averaged. In the case of some States the average was determined from the analyses for every year, and for the years before 1910 it was thus determined for all States. The average was calculated both from the tonnages by analysis grade and from the analyses actually made in every case possible, and the result for all practical purposes was the same by both methods except for two States where the total tonnage was relatively small. The tonnage for each State was then multiplied by the percentages of N, P_2O_5, and K_2O previously found as the average for that State in order to determine the tons of plant food contained. The sums of the tonnages of plant food were then divided by the total tonnage represented to obtain a weighted-average composition for the United States. For a few years figures for several States using small tonnages were missing, but for recent years practically the total consumption is represented in the weighted average.

By comparing the average composition of the mixed goods produced and consumed in the same years wherever that is possible in tables 2 and 3 it will be seen that they check fairly well. The data for individual States will be found in a later table.

TABLE 3.—*Average composition of complete mixed fertilizers consumed in stated years*

Year	Nitrogen	Available phosphoric acid	Potash	Total plant food	Year	Nitrogen	Available phosphoric acid	Potash	Total plant food
	Percent	*Percent*	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*	*Percent*
1880	2.3	8.9	2.2	13.4	1927	2.8	9.4	4.4	16.6
1890	2.3	9.2	2.4	13.9	1928	2.9	9.6	4.5	17.0
1900	2.0	9.2	2.9	14.1	1929	3.1	9.8	4.6	17.5
1910	2.2	9.0	3.7	14.9	1930	3.2	9.7	4.9	17.8
1920	2.2	8.9	2.8	13.9	1931	3.3	9.6	5.0	17.9
1925	2.6	9.3	4.1	16.0	1932	3.4	9.5	5.1	18.0
1926	2.7	9.5	4.3	16.5					

[1] Italic numbers in parentheses refer to Literature Cited, p. 20.

The average figures for the composition of the goods consumed are plotted in figure 1, which shows that the percentages of nitrogen and available phosphoric acid in mixed goods remained practically constant from 1880 to 1920 but that the potash content gradually increased until the potash shortage during the World War caused it to diminish temporarily. From 1920 to 1929 the proportions of all three elements in mixtures increased steadily, but the nitrogen and potash contents increased more rapidly than that of available phos-

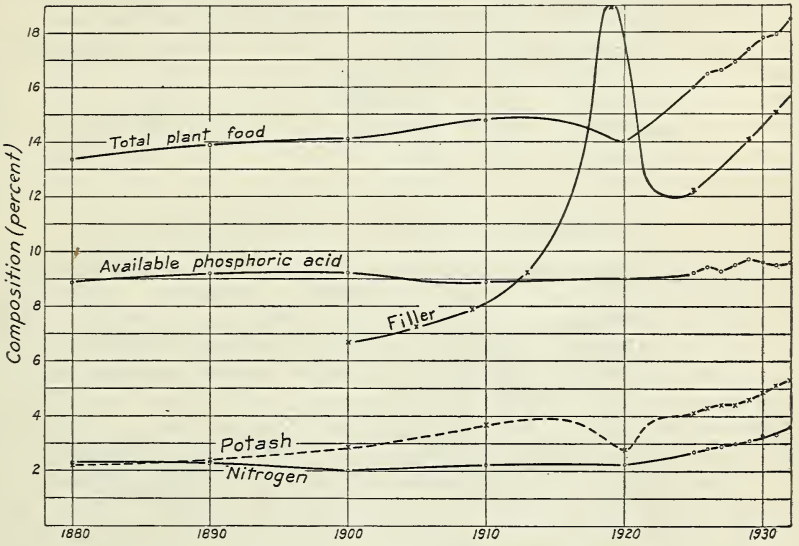

FIGURE 1.—Average composition of complete mixed fertilizer.

phoric acid. Since 1929 the percentage of the latter has decreased, but the trend of the other two is still upward.

SUPERPHOSPHATE AND POTASH MIXTURES

In recent years about 60 percent of the total tonnage of fertilizers sold has consisted of complete mixed goods. The only other kind of mixture used in considerable quantities is that containing available phosphoric acid and potash. This kind constitutes about 2 percent of the total consumption.

The average composition of superphosphate and potash mixtures was calculated in the same way and for the same years as that for the complete mixtures.

The results given in table 4 indicate that the precentage of available phosphoric acid in this kind of mixture changed very little from 1880 to about 1926 and that since that time it has increased slightly. The potash content has increased steadily since 1890 except during the World War period. The total plant-food content of this kind of mixture was practically the same as that of the complete mixtures for every year up to 1920. Since then the concentration of the incomplete mixtures has been going up more rapidly. This is due to the fact that the bulk of the superphosphate and potash mixtures is being

used in those States were the plant food content of all fertilizer mixtures is increasing rapidly.

TABLE 4.—*The average composition of superphosphate and potash mixtures in stated years*

Year	Available phosphoric acid	Potash	Total plant food	Year	Available phosphoric acid	Potash	Total plant food
	Percent	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
1880	11.5	2.0	13.5	1927	11.8	6.8	18.6
1890	11.6	1.9	13.5	1928	12.0	6.9	18.9
1900	11.5	2.3	13.8	1929	12.5	7.8	20.3
1910	11.4	3.4	14.8	1930	12.8	8.1	20.9
1920	10.3	3.3	13.6	1931	12.8	8.7	21.5
1925	11.3	6.1	17.4	1932	12.8	8.2	21.0
1926	11.6	6.4	18.0				

MATERIALS IN FERTILIZER MIXTURES

For certain years data have been collected to show the tonnage of various materials used in making fertilizer mixtures. The earliest information available is given by the American Fertilizer Hand Book (*1*) for 1900 and 1905. The Census Bureau (*5*) has published some data for 1909, 1919, 1929, and 1931. Surveys were made for 1913 by the Federal Trade Commission (*6*) and for 1917 and 1918 by Goldenweiser (*3*) of the Department of Agriculture. Additional data have been published by Brand (*2*), Walton (*7*), Turrentine (*4*), and Washburn (*8*.) The figures obtained from these reports were supplemented by additional data wherever possible from other sources. For example, the tonnage of castor pomace was determined for each of the years studied from statistics on the quantity of castor-beans consumed, on the assumption that all of the pomace was used in the fertilizer industry. Thus by various means almost the total tonnage of the ingredients used in making mixed goods in the years studied was accounted for. The tonnage of each material shown in table 5 was multiplied by the average percentage of plant food that this material had been found to contain for that year to find the number of tons of each kind supplied by it to mixtures. From these figures the percentage of nitrogen in the form of ammonia, nitrate, organic ammoniate, and water-soluble organic compounds like cyanamid, was calculated. Percentages were also obtained to show the source of phosphoric acid and potash in mixed goods.

TABLE 5.—*Materials used in manufacturing mixed fertilizers and some data regarding the resulting mixtures in stated years*

Material	1900	1905	1909	1913	1917	1919	1925	1929	1931
	Short tons	*Short tons*	*Short tons*	*Short tons*	*Short tons*	*Short tons*	*Short tons*	*Short tons*	*Short tons*
Ammonium sulphate	4,120	10,540	65,592	135,000	125,283	135,882	218,000	460,505	322,878
Nitrate of soda	17,203	40,234	89,846	149,934	285,983	152,415	230,000	240,403	106,284
Animal tankage	[1] 253,260	[1] 336,462	120,000	228,351	203,628	200,000	70,000	79,459	42,621
Garbage tankage			150,000	150,000	123,835	116,000	133,000	110,000	51,482
Bone (all kinds)	[1] 84,255	[1] 118,453	80,000	80,000	(2)	85,000	50,000	45,676	24,817
Dried blood	30,000	40,000	47,000	36,000	37,189	30,000	5,000	12,651	5,000
Fish scrap	28,977	58,437	60,000	67,000	46,003	70,000	70,000	81,215	43,579
Cottonseed meal	146,488	183,368	350,000	275,000	306,399	230,526	100,000	84,762	55,340
Castor pomace	4,747	10,500	16,698	20,418	19,948	22,964	33,946	45,000	30,529
Guano and dried manure	(2)	(2)	(2)	(2)	67,715	33,053	10,000	28,966	26,134
Cyanamid				15,488	37,230	16,926	75,000	77,389	39,509
Proprietary tankage					5,994	10,000	120,000	126,000	69,514
Ammonium phosphates					20,237	22,000	25,000	30,000	35,488
Sewage sludge						(2)	20,000	24,000	7,497
Cocoa shells and meal					9,000	11,000	16,000	13,000	12,000
Urea and calurea								20,000	9,954
Ammonium sulphate nitrate								36,317	5,000
Ammonia liquor								36,000	31,372
Ammonia, anhydrous									16,931
Other nitrogenous materials [3]	(4)	(4)	(2)	(2)	(2)	20,000	100,000	68,672	16,082
Wet-mix base goods	100,000	200,000	300,000	500,000	518,378	400,000	100,000	80,000	60,000
Superphosphate [5]	1,094,028	1,324,032	1,838,865	2,450,000	2,627,029	2,916,486	2,955,000	2,922,379	2,200,288
Double superphosphate							45,000	47,337	50,000
Muriate of potash	60,000	75,614	120,459	195,000	12,124	32,900	175,000	228,319	188,240
Sulphate of potash	9,000	15,000	30,000	33,000	13,420	79,482	75,000	77,043	63,554
Kainit	54,700	190,493	347,104	350,000	2,175	31,145	100,000	81,119	49,101
Manure salts	30,000	60,000	100,000	210,000	1,684	17,560	375,000	389,884	217,448
Tobacco stems	10,000	15,000	15,000	30,000	37,218	50,000	35,000	40,000	40,000
Wood ashes	(2)	342			6,523		1,577	675	488
Potassium nitrate (saltpeter)	884	1,160			14,478	(2)			
Other potash materials [6]	10,407	17,547	25,000	52,000	76,969	104,135	38,000	49,822	42,023
Filler [7]	140,498	211,248	324,805	511,608	1,147,101	900,170	724,292	850,778	690,798
Total mixed fertilizer	2,078,267	2,908,430	4,080,369	5,488,799	5,745,543	5,687,644	5,899,815	6,416,018	4,553,951
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Filler in mixture	6.75	7.26	7.96	9.32	19.97	18.49	12.28	13.26	15.17

[1] Includes some materials not properly belonging in this classification.
[2] Some used, but no figures available.
[3] Includes horn and hoof meal, various seed meals, calcium nitrate, etc., estimated to contain between 5 and 9 percent N.
[4] Tonnage was small and was included partly with tankage and partly with bone.
[5] Also includes dissolved bone and dissolved bone black.
[6] Includes hard salts, sylvinite, sulphate of potash-magnesia, Nebraska potash, cement flue dust, blast-furnace dust, potassium carbonate, cotton-hull ashes, Nitrapo, etc., with a K_2O content estimated to be 20 percent in 1900 and gradually increasing to 28 percent in 1931.
[7] Sand, limestone, dolomite, coal ashes, etc.

TABLE 5.—*Materials used in manufacturing mixed fertilizers and some data regarding the resulting mixtures in stated years*—Continued

WEIGHTED AVERAGE-ANALYSIS FORMULAS[8]

Material	1900	1905	1909	1913	1917	1919	1925	1929	1931
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Calculated on the basis of the materials used but without any filler	2.2–9. 9–3. 0	2. 1–9. 9–3. 4	2. 4–9. 5–4. 2	2. 4–9. 7–4. 5	3. 3–11. 7–1. 1	2. 5–12. 3–2. 1	3. 0–10. 7–4. 6	4. 2–10. 8–5. 1	3. 9–11. 8–5. 4
Calculated on same basis with filler	2. 0–9. 4–2. 8	2. 0–9. 2–3. 1	2. 2–8. 7–3. 9	2. 1–8. 8–4. 1	2. 6– 9. 4–0. 8	2. 1–10. 0–1. 7	2. 6– 9. 4–4. 0	3. 6– 9. 4–4. 4	3. 3–10. 0–4. 6
Mixed goods actually sold	2. 0–9. 2–2. 9	2. 0–9. 2–3. 1	2. 2–8. 9–3. 7	2. 2–8. 9–3. 9	2. 2– 9. 9–0. 7	2. 3– 9. 7–1. 8	2. 7– 9. 2–4. 1	3. 1– 9. 7–4. 6	3. 3– 9. 5–5. 1
TOTAL UNITS OF PLANT FOOD									
Plant food if no filler had been used	15. 1	15. 4	16. 1	16. 6	16. 1	16. 9	18. 3	20. 2	21. 1
Plant food actually contained	14. 1	14. 3	14. 8	15. 0	12. 8	13. 8	16. 0	17. 4	17. 9

[8] Percentages of nitrogen, phosphoric acid, and potash, respectively.

NITROGEN

The percentage of the total nitrogen supplied in various forms in mixed fertilizers is given in table 6. This shows that only 2 percent of the nitrogen was in the form of ammonia in 1900 but that 61 percent was in this form in 1931. The amount of nitrates used in mixtures in 1900 also appears to have been very small although larger than that of ammonia nitrogen. The use of nitrates increased as rapidly as that of ammonia until 1917 or thereabouts but has steadily declined since then. In 1900 nearly all of the nitrogen in mixed fertilizers came from organic ammoniates, but the amount of such materials going into fertilizers has diminished rapidly ever since. The first year for which tonnage figures are obtainable on the use of water-soluble organic compounds in mixed fertilizers is 1913, when 2.1 percent of the nitrogen was in the form of cyanamid. Since then urea and urea compounds have joined this class of nitrogen carriers. The use of such materials has since increased considerably.

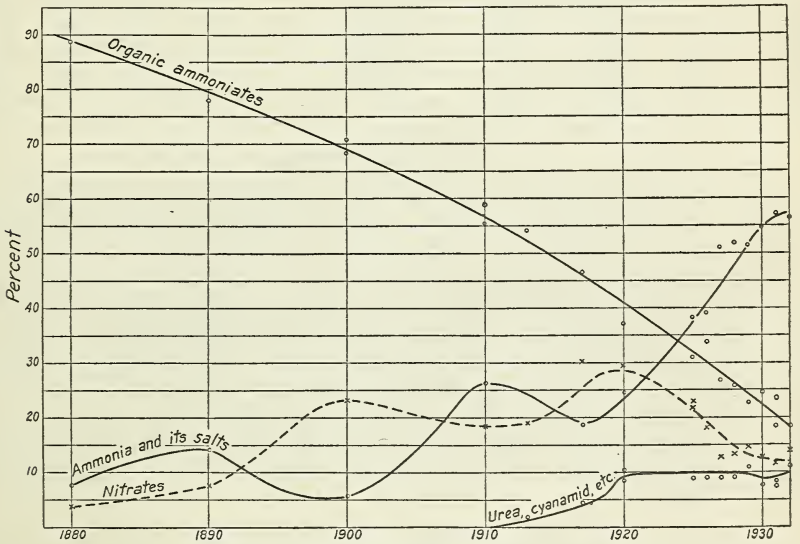

FIGURE 2.—Source of nitrogen in mixed fertilizers.

Nearly all control reports contain data on the quantities of water-soluble and insoluble nitrogen or organic and inorganic nitrogen in mixed goods. A number of the State control laboratories (those of California, Connecticut, Kentucky, Maine, Maryland, Massachusetts, New Jersey, Oregon, Rhode Island, Vermont, and Wisconsin) have published, in addition, for certain years the amounts of each of the different forms of nitrogen found by analysis in their official samples. All available data of this kind were used to work out the averages shown in table 7. These figures show the same trend as those in table 6. For such years as they were computed by both methods the data are approximately the same. In all, three sets of data were worked out by different methods and are plotted in figure 2. Smoothed curves drawn through the points show that the trend to supply less nitrogen in the form of organic ammoniates and more in the form of ammonia is still very strong.

TABLE 6.—*Source of nitrogen in all mixed fertilizers produced in stated years*

Year	Ammonia and its salts	Nitrates	Organic ammoniates	Cyanamid, urea, etc.	Year	Ammonia and its salts	Nitrates	Organic ammoniates	Cyanamid, urea, etc.
	Percent total N	*Percent total N*	*Percent total N*	*Percent total N*		*Percent total N*	*Percent total N*	*Percent total N*	*Percent total N*
1900	2.1	6.9	91.0	----	1919	23.8	19.7	53.6	2.9
1905	3.8	11.2	85.0	----	1925	29.5	23.1	37.0	10.4
1909	16.1	16.2	67.7	----	1929	48.2	19.0	22.2	10.6
1913	24.0	19.6	54.3	2.1	1931	61.2	11.6	18.8	8.4
1917	18.7	30.2	46.5	4.6					

TABLE 7.—*Source of nitrogen in complete mixed fertilizers consumed in stated years*

Year	Ammonia and its salts	Nitrates	Organic ammoniates	Cyanamid, urea, etc.	Year	Ammonia and its salts	Nitrates	Organic ammoniates	Cyanamid, urea, etc.
	Percent total N	*Percent total N*	*Percent total N*	*Percent total N*		*Percent total N*	*Percent total N*	*Percent total N*	*Percent total N*
1880	7.8	3.9	88.3	----	1927	51.0	12.9	26.9	9.2
1890	14.4	7.6	78.0	----	1928	51.7	13.3	25.7	9.3
1900	5.8	23.4	70.8	----	1929	51.3	14.8	22.6	11.3
1910	26.3	18.4	55.3	----	1930	54.7	12.8	24.6	7.9
1920	24.6	29.5	37.3	8.6	1931	57.4	11.6	23.5	7.5
1925	38.1	21.9	31.0	9.0	1932	56.4	14.0	18.3	11.3
1926	39.0	18.2	33.9	8.9					

PHOSPHORIC ACID

As will be seen in table 8, superphosphate has always supplied the bulk of the available phosphoric acid in mixed goods. In recent years it has supplied about seven eighths of it. Old-fashioned wet-mix base goods, prepared by acidulating phosphate rock and rough ammoniates, increased in importance until about 1913; since that time less and less phosphoric acid has been used in this form, because of a growing tendency to use the rough ammoniates, such as leather scrap and hair, to make proprietary tankages instead. The importance of bone, tankage, etc., as sources of phosphoric acid in mixtures is steadily declining, while the very high analysis materials, double superphosphate and ammonium phosphate, are increasing in importance.

TABLE 8.—*Source of phosphoric acid in all mixed fertilizers produced in stated years*

Year	Superphosphate	Wet-mix base goods	Organic materials [1]	Double superphosphate	Ammonium phosphate
	Percent total available P_2O_5	*Percent total available* P_2O_5	*Percent total available* P_2O_5	*Percent total available* P_2O_5	*Percent total available* P_2O_5
1900	79.8	4.6	15.6	----	----
1905	73.2	7.1	19.7	----	----
1909	80.1	8.5	11.4	----	----
1913	78.7	10.4	10.9	----	----
1917	80.5	9.6	8.1	----	1.8
1919	81.9	6.8	9.6	----	1.7
1925	87.7	2.0	5.1	3.6	1.6
1929	87.4	1.5	6.0	3.6	1.5
1931	86.6	1.5	4.6	4.8	2.5

[1] Includes bone, animal tankage, fish scrap, garbage tankage, guano, tobacco stems, cottonseed meal, dried blood, sewage sludge, etc.

POTASH

Since 1900 (table 9) the bulk of the potash in mixed goods has been derived from muriate and sulphate of potash. Although no figures are available it is understood that prior to that time kainit and wood ashes were of greater importance as sources of potash than they have ever been since. After the World War cut off the importation of kainit that material never regained its former popularity in the United States. Its place as a source of potash appears to have been taken to a considerable extent by manure salts, which contain approximately 50 percent more K_2O.

TABLE 9.—*Source of potash in all mixed fertilizers produced in stated years*

Year	High-grade salts [1]	Kainit	Manure salts	Organic materials [2]	All other sources [3]
	Percent total K_2O	*Percent total* K_2O	*Percent total* K_2O	*Percent total* K_2O	*Percent total* K_2O
1900	71.3	12.1	7.5	5.4	3.7
1905	50.6	26.6	14.5	4.5	3.8
1909	47.9	28.4	16.2	5.6	1.9
1913	51.2	20.1	19.4	3.5	5.8
1917	38.9	0.6	0.8	29.3	30.4
1919	54.6	4.2	3.6	8.8	28.8
1925	52.6	5.6	34.5	2.6	4.7
1929	54.3	4.1	34.4	3.9	3.3
1931	61.7	3.6	26.5	2.3	5.9

[1] Includes muriate, sulphate, and nitrate, but not carbonate, which is included with all other sources.
[2] Includes tobacco stems, cottonseed meal, castor pomace, garbage tankage, and guanos.
[3] Includes hard salts, sylvinite, sulphate of potash-magnesia, Nitrapo, various kinds of ashes, cement flue dust, potassium carbonate, etc.

FILLER

In 1880 practically no filler was used in mixed fertilizers, but since that time its use has steadily increased. The percentage of filler in mixed fertilizers given in table 5 for various years was determined from the difference in composition between the fertilizers actually produced and those that would have been produced if no filler had been added to the ingredients shown. The percentage of plant food supplied by each ingredient was determined by use of the average composition of the material for that year as already found in this study.

The figures for filler given in this circular, include, as has been the customary practice, all materials that do not supply nitrogen, phosphoric acid, or potash. Materials that are used (1) to supply other necessary plant-food elements such as lime, magnesia, and manganese, or (2) to neutralize physiological acidity, should not be considered as fillers. According to United States census reports, 7,158 tons of ground limestone were used by the fertilizer industry in 1899 and 20,281 tons in 1924. Lack of statistics precludes giving precise figures for the quantities of such materials that have been consumed in recent years in mixed goods, but it has been estimated that they constituted about 2 percent of the total weight of the fertilizers produced in 1931. Even assuming that 1 percent was used in 1920 and that this increased to 2 percent in 1931, and making deductions accordingly from the values given here, the conclusions to be drawn upon the use of sand and similar materials will remain substantially the same.

The results in table 5 show that the use of filler has grown steadily and was abnormally high during the World War period. The latter

was due to at least two causes: (1) The high prices of this period induced many farmers to buy lower analysis goods than they were accustomed to; and (2) the shortage of potash forced its omission from many mixtures altogether without any corresponding increase in the proportions of the other ingredients.

This increase in the amount of filler put into mixtures is greatly to be regretted since it usually serves no useful purpose in keeping with the additional cost its use adds to the product. Materials added to supply needed calcium, magnesium, manganese, or some other plant-food element although in the past usually included with filler are excepted from the previous statement and should not be considered filler. The cost of mixing, bagging, selling, transporting, storing, and applying fertilizer is so much a ton whether it contains 10 percent of plant food or 30 percent. The retail price of 1 ton of fertilizer containing about 20 percent of plant food is usually from $5 to $10 less than for the larger weight of 12- to 14-percent goods containing the same quantity of plant food.

The total number of units of plant food present in the average mixture is compared at the bottom of table 5 with what this number would have been if no filler of any kind had been used. In 1931 these figures were 17.9 and 21.1 percent. If it is assumed that 100,000 tons of the filler used in this year was valuable material and the balance had been eliminated as not worth what it cost the consumer the average mixture would have contained 20.6 percent of nitrogen, available phosphoric acid, and potash.

AVERAGE ANALYSIS OF FERTILIZERS CONSUMED IN VARIOUS STATES

It would be of interest to know whether the changes in composition shown to have occurred were the same throughout the country. In order to give some information on this point the average plant-food content of the mixed goods consumed in the various States is set forth in table 10. These figures show that the average plant-food content has increased in every State during the past 50 years, but in the Southeastern States the increase has been less. Most of these States have minimum legal limits of concentration below which fertilizers are barred from sale. The total at present is particularly low in North Carolina and Virginia. In Massachusetts, Indiana, Texas, and some other States, the total plant-food content of mixed goods is now almost exactly what the figures in table 5 indicate it should be if these mixtures were prepared from the same kind of materials and in the same proportions as for the entire country, but without any filler. This does not necessarily mean that no filler was used in these States, for higher analysis materials are used in making fertilizer mixtures in some sections than in others. In Puerto Rico and Minnesota the concentration is higher than would be possible if the materials generally used throughout the country were mixed in the usual proportions. It is known, however, that these sections consume considerable tonnages of materials of higher-than-average analysis. On the other hand it is also known that to some extent different ingredients are used in the Southeastern States and that these materials on the whole contain less plant food. Low-analysis materials of course should be used where they are economical, but the tonnage of such materials used is not enough to account for the low total concentration of mixed goods in this section.

TABLE 10.—*Average available plant food content of complete mixed fertilizers consumed in certain States, in Puerto Rico, and in the United States during stated years*

State	Plant food	1880	1890	1900	1910	1920	1925	1926	1927	1928	1929	1930	1931	1932
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Maine	N	[1] 2.8	2.4	2.0	2.5	3.0	3.5	3.6	3.7	3.9	4.3	4.4	4.7	4.8
	P_2O_5	[1] 9.3	8.1	8.5	7.9	8.5	8.0	8.9	8.7	9.0	9.4	9.8	10.1	9.9
	K_2O	[1] 2.7	3.2	4.3	6.1	4.5	7.3	6.9	7.0	7.2	7.7	7.8	8.6	8.2
	Total	[1] 14.8	13.7	14.8	16.5	16.0	18.8	19.4	19.4	20.1	21.4	22.0	23.4	22.9
New Hampshire	N	2.5	2.5	2.6	2.5	2.6	3.2	3.1	3.3	3.4	3.6	3.8	4.0	4.5
	P_2O_5	7.7	9.0	8.4	7.8	8.5	8.8	8.9	8.6	8.5	8.9	9.1	9.3	9.3
	K_2O	2.9	2.5	4.0	5.2	3.2	5.8	5.8	5.7	5.8	6.2	6.1	6.5	6.7
	Total	13.1	14.0	15.0	15.5	14.3	17.8	17.8	17.6	17.7	18.7	19.0	19.8	20.5
Vermont	N	2.8	2.4	2.1	2.2	2.6	3.0	3.1	3.2	3.1	3.2	3.5	3.6	4.1
	P_2O_5	8.6	8.9	8.5	8.3	8.5	8.2	8.5	9.5	9.9	9.5	9.5	9.7	10.1
	K_2O	2.4	3.2	4.1	5.0	2.7	5.3	5.8	6.0	7.2	7.5	7.2	7.1	7.0
	Total	13.8	14.5	14.7	15.5	13.8	16.5	17.4	18.7	20.2	20.2	20.2	20.4	21.2
Massachusetts	N	3.7	3.0	3.0	3.2	3.0	3.8	3.8	4.0	4.1	4.3	4.4	4.7	5.2
	P_2O_5	7.7	8.1	7.7	7.3	7.4	7.7	7.9	8.0	8.4	8.2	8.3	8.3	8.9
	K_2O	3.6	4.3	5.7	5.8	3.5	5.8	5.7	6.1	6.3	6.4	6.6	6.8	7.1
	Total	15.0	15.4	16.4	16.3	13.9	17.3	17.4	18.1	18.8	18.9	19.3	19.8	21.2
Rhode Island	N	------	2.9	2.8	2.8	2.5	3.3	3.5	3.5	3.7	3.7	4.0	4.1	4.8
	P_2O_5	------	7.8	8.1	7.5	8.3	8.4	8.4	8.7	8.6	8.7	8.7	9.3	9.8
	K_2O	------	4.1	5.0	5.8	3.5	5.4	5.4	5.7	5.7	5.6	5.8	6.1	6.8
	Total	------	14.8	15.9	16.1	14.3	17.1	17.3	17.9	18.0	18.0	18.5	19.5	21.4
Connecticut	N	4.2	2.9	2.7	2.9	2.8	3.6	3.7	3.8	4.1	4.2	4.3	4.6	5.2
	P_2O_5	6.6	8.8	8.7	7.8	7.8	7.6	7.8	7.8	8.1	8.0	8.0	8.5	8.8
	K_2O	3.4	4.2	4.9	5.7	3.3	5.4	5.8	5.9	6.2	6.3	6.4	6.7	6.9
	Total	14.2	15.9	16.3	16.4	13.9	16.6	17.3	17.5	18.4	18.5	18.7	19.8	20.9
New York	N	2.8	1.8	2.2	2.5	1.8	2.7	2.7	2.8	2.9	3.2	3.6	3.7	4.1
	P_2O_5	8.6	9.5	8.9	8.1	8.6	9.1	9.5	8.8	9.6	10.1	10.7	10.8	10.9
	K_2O	3.4	3.3	4.8	5.5	3.2	5.4	5.9	5.4	5.8	6.1	6.2	6.3	6.4
	Total	14.8	14.6	15.9	16.1	13.6	17.2	18.1	17.0	18.3	19.4	20.5	20.8	21.4

[1] Figures for 1884.

TABLE 10.—*Average available plant food content of complete mixed fertilizers consumed in certain States, in Puerto Rico, and in the United States during stated years*—Continued.

State	Plant food	1880	1890	1900	1910	1920	1925	1926	1927	1928	1929	1930	1931	1932
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
New Jersey	N	2.8	2.6	2.3	2.5	2.3	2.9	3.1	3.1	3.3	3.4	3.5	3.6	4.0
	P_2O_5	6.8	7.7	8.4	7.4	8.4	8.4	8.8	8.7	8.8	8.6	8.8	9.4	9.2
	K_2O	2.7	4.4	5.8	6.6	3.9	5.8	6.2	6.4	6.4	6.3	6.7	6.9	6.7
	Total	12.3	14.7	16.5	16.5	14.6	17.1	18.1	18.2	18.5	18.3	19.0	19.9	19.9
Pennsylvania	N	2.1	1.7	1.7	1.3	1.4	1.8	1.9	2.1	2.1	2.2	2.3	2.4	2.8
	P_2O_5	9.1	8.9	8.5	8.2	8.6	9.3	9.8	9.8	10.1	10.6	10.2	10.4	10.1
	K_2O	2.1	2.2	3.4	3.5	2.7	5.0	5.7	5.7	5.7	5.7	5.9	5.8	5.9
	Total	13.3	12.8	13.6	13.0	12.7	16.1	17.4	17.6	17.9	18.5	18.4	18.6	18.8
Delaware	N				1.9	1.8	2.0	2.5	2.4	2.5	2.6	2.6	2.7	3.1
	P_2O_5				8.2	8.1	8.6	8.6	8.6	8.8	8.7	8.8	8.7	8.6
	K_2O				4.2	3.2	5.3	5.4	5.6	6.2	6.1	6.0	6.3	6.1
	Total				14.3	13.1	15.9	16.5	16.6	17.5	17.4	17.4	17.7	17.8
Maryland	N	2.2	2.1	1.7	1.7	1.8	2.6	2.7	2.9	3.0	3.1	3.3	3.4	3.2
	P_2O_5	9.2	9.2	9.1	8.0	9.0	8.8	9.0	9.0	8.9	8.9	8.8	8.7	8.9
	K_2O	2.1	2.2	2.9	3.9	2.8	4.6	5.1	5.2	5.3	5.5	5.9	5.9	5.8
	Total	13.5	13.5	13.7	13.6	13.6	16.0	16.8	17.1	17.2	17.5	18.0	18.0	17.9
West Virginia	N		1.6	1.5	1.3	1.3	1.9	2.1	2.3	2.2	2.4	2.3	2.5	3.0
	P_2O_5		9.0	8.9	8.6	9.1	10.2	10.3	10.6	10.6	10.6	11.0	11.1	11.3
	K_2O		1.6	2.6	4.2	2.2	3.9	4.4	4.6	5.0	5.1	4.9	5.0	5.6
	Total		12.2	13.0	14.1	12.6	16.0	16.8	17.5	17.8	18.1	18.2	18.6	19.9
Virginia	N	2.4	3.0	2.5	2.0	3.6	4.0	3.4	3.4	3.2	3.3	3.4	3.9	3.3
	P_2O_5	9.7	8.6	8.4	8.7	7.7	7.8	8.4	8.2	8.4	8.3	8.2	7.8	8.2
	K_2O	2.3	3.0	3.1	3.3	3.7	4.3	3.9	3.9	3.8	3.9	4.1	4.6	4.1
	Total	14.4	14.6	14.0	14.0	15.0	16.1	15.7	15.5	15.4	15.5	15.7	16.3	15.6
North Carolina	N	1.9	2.0	2.3	2.5	2.3	2.5	2.6	2.6	2.7	2.6	2.7	2.7	2.6
	P_2O_5	8.6	9.1	8.8	8.3	8.1	8.4	8.6	8.6	8.6	8.6	8.5	8.3	8.3
	K_2O	2.0	2.0	2.6	3.4	2.9	3.2	3.5	3.5	3.5	3.5	3.7	3.5	3.5
	Total	12.5	13.1	13.7	14.2	13.3	14.1	14.7	14.7	14.8	14.7	14.9	14.5	14.4

South Carolina	N	[2] 2.2	2.1	2.3	2.7	2.7	2.9	2.9	2.9	3.1	3.3	3.2	3.2	3.1
	P_2O_5	[2] 8.9	9.4	9.5	8.9	8.6	9.2	9.5	9.3	9.0	9.3	9.4	9.4	9.2
	K_2O	[2] 1.7	2.0	2.1	3.3	2.9	3.4	3.6	3.5	3.8	4.0	4.2	4.2	4.0
	Total	[2] 12.8	13.5	13.9	14.9	14.2	15.5	16.0	15.7	15.9	16.6	16.8	16.8	16.3
Georgia	N	2.1	2.3	1.8	1.9	2.0	2.6	2.6	2.6	2.6	2.7	2.8	2.8	2.6
	P_2O_5	9.5	10.2	10.4	9.8	9.5	9.8	9.7	9.4	9.8	9.9	10.0	9.7	9.3
	K_2O	1.4	1.9	2.1	3.2	2.7	3.8	3.9	3.9	4.1	4.0	4.4	4.3	4.2
	Total	13.0	14.4	14.3	14.9	14.2	16.2	16.2	15.9	16.5	16.6	17.2	16.8	16.1
Florida	N		3.1	3.0	3.2	3.3	3.2	3.5	3.6	3.5	3.4	3.7	3.8	4.3
	P_2O_5		7.8	7.2	7.2	7.5	7.5	7.9	7.8	8.4	7.9	8.2	8.3	8.4
	K_2O		6.6	7.8	7.6	3.5	5.4	6.0	5.6	5.2	5.7	6.1	6.0	6.1
	Total		17.5	18.0	18.0	14.3	16.1	17.4	17.0	17.1	17.0	18.0	18.1	18.8
Alabama	N		2.2	1.6	1.7	1.8	2.4	2.6	2.7	2.8	2.8	2.9	2.8	2.9
	P_2O_5		8.8	11.0	11.2	11.0	10.7	10.5	10.4	10.2	10.2	10.1	9.8	10.0
	K_2O		1.8	1.9	2.7	2.5	4.0	4.1	4.2	4.3	4.3	4.3	4.3	4.5
	Total		12.8	14.5	15.6	15.3	17.1	17.2	17.3	17.3	17.3	17.3	16.9	17.4
Mississippi	N	[3] 2.1	2.3	1.7	1.7	1.7	2.5	2.9	3.0	3.3	3.9	4.1	4.0	4.0
	P_2O_5	[3] 9.8	9.3	9.7	10.3	10.0	10.2	10.3	9.9	9.7	9.5	9.0	8.8	9.0
	K_2O	[3] 2.0	2.1	1.9	1.9	1.9	3.0	3.2	3.3	3.6	4.1	4.1	4.1	4.2
	Total	[3] 13.9	13.7	13.3	13.9	13.6	15.7	16.4	16.2	16.6	17.5	17.2	16.9	17.2
Tennessee	N			2.2	1.8	1.4	2.1	2.5	2.5	2.7	2.8	3.2	3.3	3.0
	P_2O_5			8.8	10.1	10.1	10.1	10.3	10.3	10.2	10.5	10.3	9.9	9.7
	K_2O			2.1	3.1	1.6	3.6	4.0	3.9	4.4	4.3	4.6	4.9	4.7
	Total			13.1	15.0	13.1	15.8	16.8	16.7	17.3	17.6	18.1	18.1	17.4
Kentucky	N	[1] 2.4	2.2	1.8	1.5	1.3	1.7	1.7	1.9	2.0	2.7	3.2	3.3	[4]
	P_2O_5	[1] 9.5	8.4	9.3	9.1	10.6	10.2	10.6	10.8	11.0	11.0	11.2	10.9	[4]
	K_2O	[1] 2.3	2.4	2.7	3.6	2.1	3.6	3.9	4.2	4.4	4.9	5.2	5.3	[4]
	Total	[1] 14.2	13.0	13.8	14.2	14.0	15.5	16.2	16.9	17.4	18.6	19.6	19.5	[4]
Ohio	N	2.5	2.0	1.8	1.9	1.3	1.1	1.3	1.4	1.6	2.2	2.3	2.4	2.3
	P_2O_5	7.8	8.6	8.7	8.7	10.5	10.9	10.9	10.6	11.7	12.8	12.9	12.7	12.6
	K_2O	2.1	2.2	2.6	4.4	1.3	5.2	5.0	5.1	5.3	5.6	5.7	5.4	4.9
	Total	12.4	12.8	13.1	15.0	13.1	17.2	17.2	17.1	18.6	20.6	20.9	20.5	19.8

[1] Figures for 1884.

[2] Figures for 1882.

[3] Figures for 1883.

[4] Necessary data not available.

TABLE 10.—*Average available plant food content of complete mixed fertilizers consumed in certain States, in Puerto Rico, and in the United States during stated years*—Continued

State	Plant food	1880	1890	1900	1910	1920	1925	1926	1927	1928	1929	1930	1931	1932
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Indiana	N	3.4	2.1	1.6	1.3	1.1	1.7	1.7	1.8	1.9	2.4	2.3	2.6	2.6
	P_2O_5	7.3	8.4	8.3	9.0	10.3	11.7	12.4	12.8	12.9	13.4	13.7	13.7	13.7
	K_2O	2.1	1.8	1.7	3.5	2.1	4.1	4.4	4.5	5.1	5.6	7.0	6.5	6.5
	Total	12.8	12.3	11.6	13.8	13.5	17.5	18.5	19.1	19.9	21.4	23.0	22.8	22.8
Illinois	N		2.7	2.1	1.9	1.8	2.8	2.9	2.7	2.6	2.9	3.0	3.2	3.4
	P_2O_5		9.2	8.6	8.8	9.1	10.9	11.0	11.4	12.2	12.7	12.6	11.9	11.7
	K_2O		1.9	2.6	5.5	2.9	5.2	5.5	5.4	5.8	5.9	6.2	6.7	7.0
	Total		13.8	13.3	16.2	13.8	18.9	19.4	19.5	20.6	21.5	21.8	21.8	22.1
Michigan	N	3.1	2.5	2.0	1.6	1.2	2.0	2.2	2.2	2.2	2.5	2.6	2.5	2.4
	P_2O_5	8.2	8.9	8.6	9.5	9.7	10.0	10.7	11.6	12.5	12.4	12.3	12.3	12.2
	K_2O	2.1	2.6	2.9	4.4	2.5	6.0	6.1	6.6	6.0	6.1	6.3	6.0	6.5
	Total	13.4	14.0	13.5	15.5	13.4	18.0	19.0	20.4	20.7	21.0	21.2	20.8	21.1
Wisconsin	N			3.3	2.4	2.1	3.4	3.5	3.5	2.6	2.8	2.9	3.0	2.9
	P_2O_5			6.8	8.8	8.8	11.2	11.3	11.1	11.5	12.4	12.8	12.6	12.3
	K_2O			5.8	6.0	2.7	4.9	5.2	5.5	5.9	6.5	7.4	8.8	7.0
	Total			15.9	17.2	13.6	19.5	20.0	20.1	20.0	21.7	23.1	24.4	22.2
Minnesota	N						3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.0
	P_2O_5						8.6	10.1	9.8	10.6	13.4	14.1	14.6	12.9
	K_2O						4.1	5.2	5.3	5.3	4.9	5.8	6.5	7.5
	Total						15.8	18.3	18.1	18.9	21.3	23.0	24.3	23.4
Iowa	N												2.1	2.2
	P_2O_5												11.6	11.8
	K_2O												7.3	7.3
	Total												21.0	21.3
Missouri	N		[5] 3.0	2.1	1.5	1.3	1.6	1.6	1.6	1.7	2.1	2.2	2.3	2.3
	P_2O_5		[5] 7.1	10.0	8.4	9.8	11.8	12.3	12.2	11.7	12.6	12.8	12.8	13.0
	K_2O		[5] 3.4	2.7	2.4	1.5	2.5	2.7	2.8	2.9	3.0	3.3	3.3	3.3
	Total		[5] 13.5	14.8	12.3	12.6	15.9	16.6	16.6	16.3	17.7	18.3	18.4	18.6

Arkansas	N		2.1	2.2	1.9	1.8	2.9	3.3	3.4	3.8	3.8	3.9	3.9	3.4
	P_2O_5		10.0	9.9	9.3	10.5	10.3	10.5	10.3	10.4	10.5	10.7	10.5	10.1
	K_2O		2.0	2.2	2.1	1.5	2.9	3.4	3.6	3.6	4.1	4.5	4.6	4.3
	Total		14.1	14.3	13.3	13.8	16.1	17.2	17.3	17.8	18.4	19.1	19.0	17.8
Louisiana	N		2.0	2.4	2.2	1.9	2.6	3.0	3.2	3.4	3.9	4.1	4.0	3.9
	P_2O_5		7.3	9.9	10.0	10.2	10.6	11.0	10.7	10.8	10.9	10.5	10.6	11.3
	K_2O		2.0	1.8	2.5	2.2	3.5	3.9	3.7	3.8	4.3	4.3	4.6	4.7
	Total		11.3	14.1	14.7	14.3	16.7	17.9	17.6	18.0	19.1	18.9	19.2	19.9
Texas	N			[6] 2.4	2.3	2.1	2.7	3.1	3.3	3.6	3.8	4.0	4.5	4.7
	P_2O_5			[6] 9.0	9.6	9.8	10.3	10.8	10.9	10.9	10.8	10.4	10.8	10.9
	K_2O			[6] 3.1	3.0	1.7	3.2	3.6	3.7	3.7	3.9	4.2	5.1	5.6
	Total			[6] 14.5	14.9	13.6	16.2	17.5	17.9	18.2	18.5	18.6	20.4	21.2
Kansas	N				2.5	1.3	2.4	2.0	1.8	2.0	2.0	2.4	2.8	2.9
	P_2O_5				4.9	11.6	11.9	12.2	12.8	12.9	13.9	13.5	13.6	13.6
	K_2O				3.5	1.2	2.8	2.7	2.5	2.7	2.7	3.6	3.6	3.8
	Total				10.9	14.1	17.1	16.9	17.1	17.6	18.6	19.5	20.0	20.3
Oklahoma	N											3.8	3.8	4.0
	P_2O_5											11.3	10.6	9.9
	K_2O											5.4	6.3	6.7
	Total											20.5	20.7	20.6
North Dakota	N											3.7	5.5	3.8
	P_2O_5											14.1	13.3	14.0
	K_2O											7.0	5.4	3.1
	Total											24.8	24.2	20.9
New Mexico	N											4.5	4.3	4.6
	P_2O_5											11.1	13.5	12.2
	K_2O											4.7	4.2	4.6
	Total											20.3	22.0	21.4
Washington	N					[7] 3.3	3.9	3.9	4.3	4.7	4.6	4.6	4.5	5.0
	P_2O_5					[7] 8.2	8.3	8.8	7.8	7.9	8.1	8.2	8.2	7.9
	K_2O					[7] 4.2	5.4	6.5	6.5	6.7	6.9	7.2	7.4	7.3
	Total					[7] 15.7	17.6	19.2	18.6	19.3	19.6	20.0	20.1	20.2

[5] Figures for 1895.

[6] Figures for 1902.

[7] Figures for 1921.

TABLE 10.—*Average available plant food content of complete mixed fertilizers consumed in certain States, in Puerto Rico, and in the United States during stated years*—Continued

State	Plant food	1880	1890	1900	1910	1920	1925	1926	1927	1928	1929	1930	1931	1932
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Oregon	N			[8] 2.4	4.2	3.0	3.8	3.9	3.3	3.4	4.1	4.5	4.2	4.2
	P_2O_5			[8] 8.4	6.3	7.7	8.0	8.2	7.7	8.1	8.7	9.0	9.0	9.2
	K_2O			[8] 5.9	5.8	2.6	6.0	6.1	6.2	6.5	7.2	7.1	7.0	7.3
	Total			[8] 16.7	16.3	13.3	17.8	18.2	17.2	18.0	20.0	20.6	20.2	20.7
California	N			[9] 3.4	3.9	4.4	5.0	5.5	6.2	6.4	6.6	6.6	6.8	6.9
	P_2O_5			[9] 7.7	7.7	7.8	7.4	7.2	7.0	6.9	7.7	7.6	7.2	8.2
	K_2O			[9] 4.6	4.0	2.6	4.9	5.5	4.7	5.5	5.9	5.6	5.6	5.6
	Total			[9] 15.7	15.6	14.8	17.3	18.2	17.9	18.8	20.2	19.8	19.6	20.7
Puerto Rico	N				5.1	7.9	7.9	8.6	9.4	9.1	9.7	9.4	8.8	10.4
	P_2O_5				7.4	8.1	7.4	7.4	6.6	6.6	6.5	6.9	6.4	6.0
	K_2O				6.8	4.7	5.2	5.7	5.2	5.2	5.2	6.7	8.5	9.5
	Total				19.3	20.7	20.5	21.7	21.2	20.9	21.4	23.0	23.7	25.9
Weighted average [10]	N	2.3	2.3	2.0	2.2	2.2	2.6	2.7	2.8	2.9	3.1	3.2	3.3	3.4
	P_2O_5	8.9	9.2	9.2	9.0	8.9	9.3	9.5	9.4	9.6	9.8	9.7	9.6	9.5
	K_2O	2.2	2.4	2.9	3.7	2.8	4.1	4.3	4.4	4.5	4.6	4.9	5.0	5.1
	Total	13.4	13.9	14.1	14.9	13.9	16.0	16.5	16.6	17.0	17.5	17.8	17.9	18.0

[8] Figures for 1903.
[9] Figures for 1904.
[10] The figures for each State were given a weight equal to the number of tons of fertilizer sold in that year in that State.

For the few States from which the necessary data could be secured the amount of filler placed in mixtures was calculated by the method previously explained for the entire country. This indicates that in Maryland 17 percent, and in North Carolina 21 percent of the average mixture is filler. On the other hand, California mixtures appear to contain only 4 percent of filler, and the facts brought out in this study indicate that in some States practically no filler is employed in fertilizer mixtures. In fact in Minnesota many of the best selling brands are guaranteed not to contain added filler.

SUMMARY

During recent years the supply of organic ammoniates of fertilizer grade has not been sufficient to meet the demand, but a large number of new fertilizer materials have been introduced. These new materials contain much higher percentages of plant food as a class than the materials formerly used in mixed fertilizers. During the same period the average plant-food content of most of the older fertilizer materials like superphosphate and kainit has steadily increased. It is therefore necessary to make fertilizer mixtures of higher analysis than formerly or to dilute the materials now available with filler.

The changes that have occurred in the composition of fertilizers in the last 50 years have been studied by examining and averaging more than a million published determinations. Many of these averages were weighted on the basis of the tonnage of each kind consumed.

The average complete mixed fertilizer in 1880 contained 2.3 percent of nitrogen, 8.9 percent of available phosphoric acid, 2.2 percent of potash, and 13.4 percent of total available plant food. In 1932 these figures were 3.4 percent of nitrogen, 9.5 percent of available phosphoric acid, 5.1 percent of potash and 18.0 percent of total available plant food. Figures for intermediate years have been given and show that most of the changes in composition have occurred in the last 10 years. Like figures for phosphate and potash mixtures show that changes of similar character and extent have occurred in them also. In 1880 the average complete mixed fertilizer included 1.7 percent, in 1925, 0.6 percent, and in 1932, 0.8 percent more plant food than it was guaranteed to contain.

In 1900 the nitrogen in all mixed fertilizers was derived 2.1 percent from ammonium salts, 6.9 percent from nitrates and 91 percent from organic ammoniates. In 1931, 61.2 percent was derived from ammonia and its compounds, 11.6 percent from nitrates, 18.8 percent from organic ammoniates, and 8.4 percent from cyanamid and urea. The source of each of the plant-food elements in mixtures has been given for a number of years.

In 1880 practically no filler was used in mixtures. In 1931 the average content of filler in mixed fertilizers was 15.2 percent. If no filler had been used such fertilizer would have contained over 21 percent of plant food instead of 17.9 percent.

The statistics collected in this study show that in some States very little change has been made in the average grade of fertilizers consumed, and that much filler is now used in mixtures. In other States, the average analysis of mixed fertilizers has steadily increased since 1920, and very little filler is used. The highest average analyses were found in those sections where farmers have only recently begun to use fertilizers.

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